

The relationship of structure and regeneration of broad-leaved Korean pine forest on the north slope of Mt. Changbai

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Abstract Studies were carried out on the spatial patterns of dominant species and gaps, and the influence of which on the regeneration in the broad-leaved Korean pine forest on the north slope of Mt. Changbai. The result showed that many deciduous tree species have high growth rates and become more competitive due to the more mild and humid climate at Mt. Changbai. No obvious aggregated distribution pattern was showed. In this forest small gaps are most frequent, with even distribution, which may be beneficial to survival and growth of *Pinus koraiensis* saplings.

Key word: Korean pine forest, Canopy gap, Structure.

Introduction

Ecological studies have been conducted in the Broad-leaved Korean pine forest at Mt. Changbai for many years^[1]. Since the introduction of the concept of gap phase regeneration, relationship between gap and regeneration of the forest has obtained more attention. Detailed investigation on species composition, vegetation structure and their role in determining gap regime is lacking however.

The aim of the present study is to get a detailed measure of the spatial patterns of canopy trees and relate this to the gap formation, gap size and their role in regeneration of the forest.

Study site and methods

The broad-leaved Korean pine forest under study is situated on the north slope of Mt. Changbai. Its elevation is about 740 m. The dominant species consist of *Pinus koraiensis*, *Tilia amurens*, *Acer mono*. Canopy height varies from 25 to 30 m. Some oldest individuals of the *Pinus koraiensis* reach an age of 200a approximately. There are many small understorey species such as *Acer spp.*

A 0.8 hm² study plot without signs of recent disturbance was chosen, the plot was grided into 2m × 2m squares. Within each square, all individuals of woody species were identified and recorded, DBH of the ones with DBH ≥ 2.0 cm were measured, and the canopy species covering the square was identified, then we can classify seedlings and saplings as growing in a gap or under the canopy.

Results

Spatial patterns of dominant tree species

The forest under study has a high proportion of deciduous tree species, and many of them show high growth rates and become more competitive due to the more mild and

humid climate at Mt. Changbai, compared with other broad-leaved Korean pine forests elsewhere. Number and basal area of *Pinus koraiensis* only account for 30% of the stand. The variance/mean method was used to analyze the spatial patterns of *Pinus koraiensis*, *Tilia amurens* and *Acer mono* of different DBH classes.

Table 1. Dispersal Coefficient of the dominant tree species

DBH class	<i>Pinus koraiensis</i>	<i>Tilia amurens</i>	<i>Acer mono</i>
≤ 10cm	0.00	1.23*	1.20*
> 10cm	0.04	0.04	0.02

In the stand, seedlings and saplings of *Acer mono* and *Tilia amurens* are numerous (DBH ≤ 10cm)^[2]. Individuals of *Acer mono* with a DBH ≤ 10 cm have a number of 741 stems/hm², and *Tilia amurens*, 285 stems/hm². They show obvious tendency of aggregated distribution based on dispersal coefficients. When individuals approach maturity, their densities decline rapidly, and the aggregated distribution no longer exists (Fig 1).

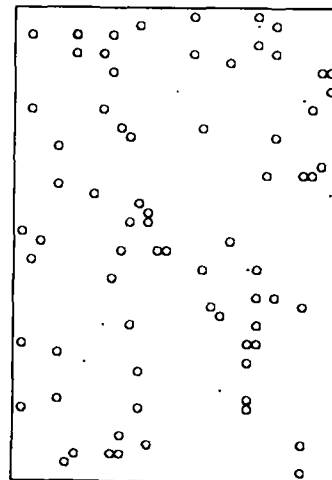


Fig. 1. Distribution of individuals of *Pinus koraiensis*

o--individuals with DBH > 10 cm; •--Individuals with DBH < 10 cm

Pinus koraiensis has a low number in the stand, its

individuals of the same DBH class are often coupled. In broad-leaved Korean pine forest of Liangshui natural reserve, the canopy trees of *Pinus koraiensis* have an appearance of mosaics of patches of various development phases due to the predominant basal area of *Pinus koraiensis* in the stand. When individuals of a patch reach maturity, most of them would die and fall, leading to the formation of a large gap^[3]. The case is the reverse at Mt. Changbai however, *Pinus koraiensis* with less proportion can not 'control' the stand. The predominance of deciduous species would cause occurrence of small gaps in this stand (Fig.2, 3).

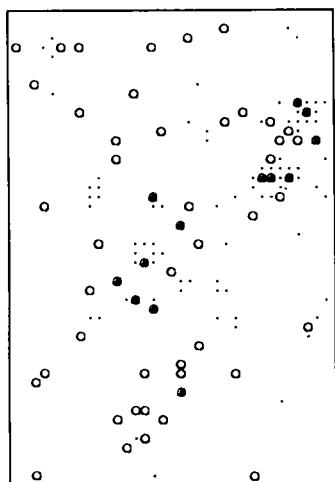


Fig. 2. Distribution of individuals of *Tilia amurensis*

o--Individuals with DBH>10 cm; •--Individuals with DBH< 10 cm

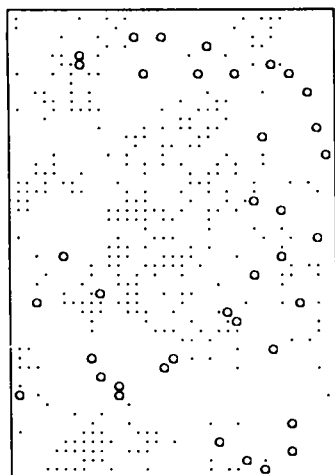


Fig. 3. Distribution of individuals of *Acer mono.*

o--individuals with DBH>10 cm; •--Individuals with DBH< 10 cm

Table 2. Gap size distribution

Range of gap size (m ²)						Total number	Total area
20-40	40-60	60-80	80-100	100-200	200-1000		
12	6	0	3	5	2	28	2560

Influence of horizontal distribution of canopy trees on gap

gap size

Gap size is an important feature of a gap, affecting the environment within a gap, and plays a role in determination of growth and regeneration of tree species^[4, 5]. The gaps described are the canopy openings by vertical projection. Usually the gap size is confined to 4~1000 m². Considering the crown size of canopy individuals of Mt. Changbai, only gaps larger than 20 m² are taken into account (Fig. 4).

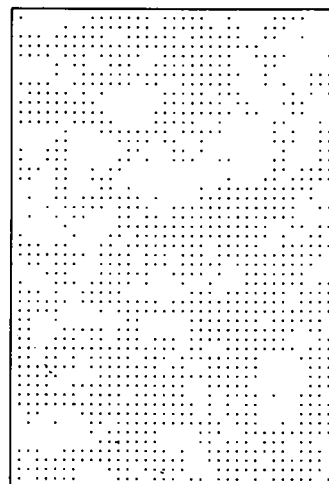


Fig. 4. Gap distribution

Horizontal distribution of gap

There are 28 gaps /hm² with a total area of 2560 m² in the study plot, including many small evenly distributed gaps (<100 m²) and several larger gaps (Table 2). Such size distribution of gaps can cause a high heterogeneity of habitats, and great changes in the availability of resources to the trees under canopy.

At Mt. Changbai, the proportion of deciduous species is high in Broad-leaved Korean pine forest, and accounts for 70% of the total basal area. These deciduous species are characterized of high growth rate and variable life span. Individuals of the forest begin fall or die standing when the DBH reaches 20~30 cm, the dead individuals with a DBH ≥ 50 cm are very few however. We observed the falling trees have small DBH classes, and a gap is formed usually by less than 4 gap-makers^[6]. The combination of the fact mentioned above would cause frequent occurrence of small, evenly distributed gaps.

Effect of gap on the regeneration of dominant tree species
Young individuals of *Pinus koraiensis* are usually distributed in or near gaps, thus they can get more light due to the evenly distributed gaps in the forest and have more opportunities to grow up into canopy (Fig. 5).

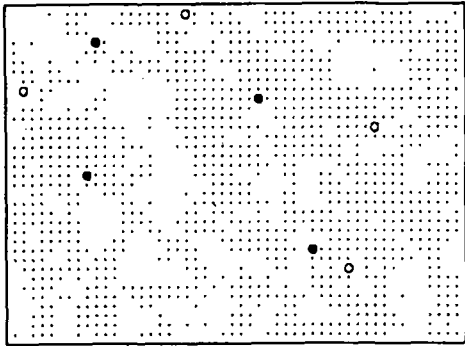


Fig. 5. Distribution of gap and young individuals of *Pinus koraiensis*

o--Seedlings and saplings of *Pinus koraiensis*

Yang Hanxi et al. (1994) studied the relationship of disturbances and radial growth of Broad-leaved Korean pine forest on western slope of Mt. Changbai, they suggested a total of 355 release events occurred for 253 individuals of canopy species before they reached canopy, 1.4 release events would be experienced for each individual on an average, which shows that more than one event of canopy opening occurred during the development period from saplings to canopy trees, providing the individuals with more opportunities to reach the canopy, especially for those of *Pinus koraiensis*^[7]. We can conclude that *Pinus koraiensis* can exist in the forest with a low number of saplings and more opportunities of survival and growth.

Densities of young individuals of *Tilia amurens* are 285 stems/hm² and 283 stems/hm² respectively under canopy and in the gaps. There is a total of 199 in the plot, including 69 in the gaps (Fig. 6).

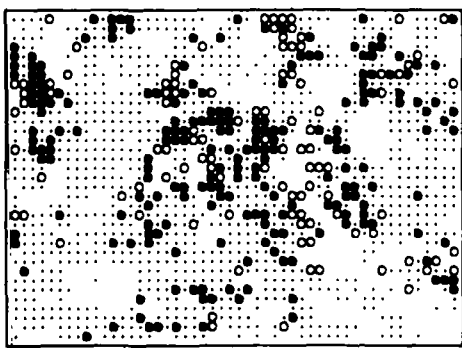


Fig. 6. Distribution of gaps and young individuals of *Tilia amurens*

o--Seedlings and saplings of *Tilia amurens*

There are many seedlings and saplings of *Acer mono*, with densities under canopy and in the gaps of 742 stems/hm² and 734 stems/hm² respectively. Individuals under canopy are far more than those in gaps due to the small proportion of gaps in the forest. There is a sum of 518 young individuals in the plot, including 179 in gaps (Fig. 7)

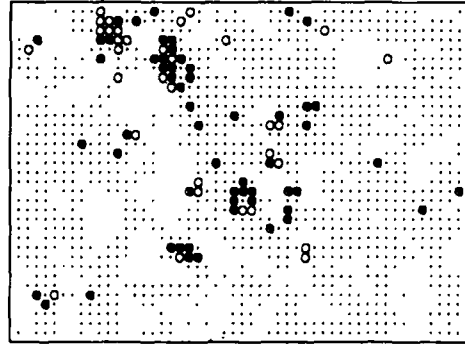


Fig. 7. Distribution of gap and young individuals of *Acer mono*

o--Seedlings and saplings of *Acer mono*

Conclusions

- Seedlings and saplings of *Acer mono* and *Tilia amurens* have a tendency of aggregated distribution in Broad-leaved Korean pine forest at Mt. Changbai. Individuals of canopy however, have not such tendency.
- There are more tree species with rapid growth and various life spans due to more mild and humid climate in this region, leading to frequent occurrence of small, evenly distributed gaps.
- Saplings of *Pinus koraiensis* are usually distributed in centers or borders of gaps. The gaps regime is beneficial to survival and growth of saplings of *Pinus koraiensis*.

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